

WHAT IS CLAIMED IS:

1. A supercharging device for an internal combustion engine, the engine comprising an intake passage, the device comprising:

a first compressor installed in the intake passage, the compressor being driven by exhaust gas energy and supercharging intake air in the intake passage;

a second compressor installed in the intake passage between the first compressor and engine, the second compressor being driven by an electric motor and supercharging air discharged from the first compressor; and a bypass valve which bypasses the second compressor, the bypass valve being open when the second compressor is not operating, and starting to close at a certain time after the second compressor starts to operate.

2. The supercharging device as defined in Claim 1, wherein the supercharging device further comprises a sensor which detects a flowrate parameter relating to an air flowrate of the bypass valve, and a programmable controller programmed to determine whether or not the flowrate of the bypass valve is zero based on the flowrate parameter, and starts closing the bypass valve when the air flowrate of the bypass valve is zero.

3. The supercharging device as defined in Claim 2, wherein the flowrate parameter detecting sensor comprises an air flowmeter which detects a total intake air flowrate of the engine, a pressure sensor which detects a pressure of the intake passage upstream of the bypass valve, a rotation speed sensor which detects a

rotation speed of the compressor, and an air temperature sensor which detects a temperature of the air pressurized by the compressor, and the controller is further programmed to calculate a discharge flowrate of the second compressor from the pressure upstream of the bypass valve, the rotation speed of the compressor and the temperature of the air pressurized by the second compressor, and determine that the air flowrate of the bypass valve is zero when the discharge flowrate of the second compressor is equal to the total intake air flowrate of the engine.

4. The supercharging device as defined in Claim 2, wherein the flowrate parameter detecting sensor comprises a sensor which detects an air flowrate of the bypass valve.

5. The supercharging device as defined in Claim 2, wherein the supercharging device further comprises an electric motor which drives the second compressor, the flowrate parameter detecting sensor comprises an air flowmeter which detects a total intake air flowrate of the engine, a voltmeter which detects a voltage supplied to the electric motor and an ammeter which detects a current supplied to the electric motor, and the controller is further programmed to calculate a rotation speed of the electric motor from the voltage and current supplied to the electric motor, calculate a rotation speed of the second compressor from the rotation speed of the electric motor, calculate a discharge flowrate of the second compressor from a predetermined discharge flowrate per unit rotation of the second compressor and the rotation speed of the second compressor, and determine that the air flowrate of the bypass valve is zero when the discharge flowrate of the second compressor is equal to the total intake air flowrate of the engine.

6. The supercharging device as defined in Claim 1, wherein the supercharging device further comprises a pressure sensor which detects a first pressure of the intake passage between the first compressor and second compressor, a pressure sensor which detects a second pressure of the intake passage between the second compressor and engine, and a programmable controller further programmed to compare the first pressure and the second pressure, and when the first pressure is more than the second pressure during operation of the second compressor, open the bypass valve and stop operation of the second compressor.

7. The supercharging device as defined in Claim 2, wherein the engine further comprises a throttle which adjusts a total intake air flowrate of the engine, the supercharging device further comprises a sensor which detects an operation speed of the throttle, and the controller is further programmed to start the second compressor when the operation speed of the throttle is more than a predetermined speed.

8. The supercharging device as defined in Claim 2, wherein the internal combustion engine is an engine which drives a vehicle, the vehicle comprising an accelerator pedal, the supercharging device further comprises a sensor which detects an accelerator pedal depression amount, and the controller is further programmed to start the second compressor when the accelerator pedal depression amount is more than a predetermined amount.

9. The supercharging device as defined in Claim 1, wherein the supercharging

device further comprises a sensor which detects a total intake air flowrate of the engine, and a programmable controller programmed to calculate a target rotation speed of the second compressor according to the total intake air flowrate of the engine, calculate a predicted rotation speed of the second compressor after a predetermined time has elapsed from the present time, and start to close the bypass valve when the predicted rotation speed has reached the target rotation speed.

10. The supercharging device as defined in Claim 9, wherein the predetermined time is set equal to the time required for closure of the bypass valve.

11. The supercharging device as defined in Claim 9, wherein the supercharging device further comprises a sensor which detects a rotation speed of the second compressor, and the controller is further programmed to calculate the predicted rotation speed based on the rotation speed of the second compressor.

12. The supercharging device as defined in Claim 11, wherein the controller is further programmed to calculate a rotation increase rate estimation value from the rotation speed of the second compressor at the present time, the rotation increase rate estimation value decreasing according to an increase of the rotation speed of the second compressor, and calculate the predicted rotation speed from the rotation increase rate estimation value and the rotation speed of the second compressor at the present time.

13. The supercharging device as defined in Claim 12, wherein the controller is further programmed to calculate a real rotation increase rate from the rotation speed of the second compressor, and correct the rotation increase rate estimation value based on the real rotation increase rate.

14. The supercharging device as defined in Claim 12, wherein the supercharging device further comprises a drive motor which drives the second compressor and a sensor which detects a current supplied to the electric motor, and the controller is further programmed to correct the predicted rotation speed based on the current supplied to the electric motor of the second compressor.

15. The supercharging device as defined in Claim 12, wherein the supercharging device further comprises a drive motor which drives the second compressor and a sensor which detects a voltage supplied to the electric motor, and the controller is further programmed to correct the predicted rotation speed based on the voltage supplied to the electric motor of the second compressor.

16. The supercharging device as defined in Claim 1, wherein the supercharging device further comprises an air flowmeter which detects a total intake air flowrate of the engine, and a programmable controller programmed to calculate a target rotation speed of the second compressor according to the total intake air flowrate, calculate a predicted rotation speed of the second compressor after a predetermined time has elapsed from startup of the second compressor, and start closure of the bypass valve when the target rotation speed coincides with the predicted rotation speed.

17. The supercharging device as defined in Claim 1, wherein the supercharging device further comprises a sensor which detects a parameter relating to fixing of the bypass valve in a closed position, and a programmable controller programmed to determine whether or not the bypass valve is fixed in the closed position based on the parameter, and supply power to the electric motor to operate the second compressor when the bypass valve is fixed in the closed position.

18. The supercharging device as defined in Claim 17, wherein the controller is further programmed to perform a determination as to whether or not the bypass valve is fixed in the closed position at a fixed interval after a predetermined time has elapsed from startup of the second compressor, and perform the determination at a shorter interval than the fixed time interval until the predetermined time has elapsed from startup of the second compressor.

19. The supercharging device as defined in Claim 17, wherein the controller is further programmed to supply a fixed power to the electric motor when the bypass valve is fixed in the closed position.

20. The supercharging device as defined in Claim 17, wherein the internal combustion engine is an engine which drives a vehicle, the vehicle comprising an accelerator pedal, the supercharging device further comprises a sensor which detects an accelerator pedal depression, and the controller is further programmed to set a target running speed of the vehicle according to the accelerator pedal depression, and to supply power to the electric motor according to the target running speed.

21. The supercharging device as defined in Claim 20, wherein the vehicle further comprises an alternator driven by the engine and a battery which stores power generated by the alternator and supplies power to the electric motor, the supercharging device further comprises a sensor which detects a state of charge of the battery and a sensor which detects a power generation state of the alternator, and the controller is further programmed to decrease the target running speed when the state of charge of the battery has not reached a predetermined state of charge and the power generation state of the alternator has not reached a predetermined power generation state.

22. The supercharging device as defined in Claim 17, wherein the parameter detecting sensor comprises a pressure sensor which detects a pressure of the intake passage between the second compressor and the engine, and the controller is further programmed to determine that the bypass valve is fixed in the closed position when the pressure is equal to or less than a predetermined pressure after the operation of the second compressor has stopped.

23. The supercharging device as defined in Claim 17, wherein the internal combustion engine is an engine which drives a vehicle, the vehicle comprising an accelerator pedal, the engine comprises a throttle which is installed in the intake passage downstream of the bypass valve and increases or decreases a total intake air flowrate of the engine according to an operation of the accelerator pedal, the parameter detecting sensor comprises an air flowmeter which detects the total intake air flowrate of the engine, a rotation speed sensor which detects a rotation

speed of the engine, and a throttle opening sensor which detects an opening of the throttle, and the controller is further programmed to determine that the bypass valve is fixed in the closed position when the total intake air flowrate detected by the air flowmeter when the operation of the second compressor has stopped is less than an intake air flowrate of the engine calculated from the rotation speed of the engine and the opening of the throttle.

24. The supercharging device as defined in Claim 17, wherein the parameter detecting sensor comprises an opening and closing sensor which detects whether or not the bypass valve is in the closed position, and the controller is further programmed to determine that the bypass valve is fixed in the closed position when the bypass valve is still in the closed position after the operation of the second compressor has stopped.

25. The supercharging device as defined in Claim 1, wherein the supercharging device further comprises a bypass passage which connects the intake passage upstream of the second compressor and the intake passage downstream of the second compressor, the bypass valve being provided in the bypass passage, and an intercooler which cools the intake air, the intercooler being installed in the intake passage upstream of the second compressor between a branch point of the intake passage with the bypass passage and the first compressor.

26. The supercharging device as defined in Claim 25, wherein the supercharging device further comprises a second intercooler which cools the intake air, the second intercooler being installed in the intake passage downstream of the second

compressor between a branch point of the intake passage with the bypass passage and the engine.

27. The supercharging device as defined in Claim 1, wherein the supercharging device further comprises a bypass passage which connects the intake passage upstream of the second compressor and the intake passage downstream of the second compressor, the bypass valve being provided in the bypass passage, a first intercooler, installed in the intake passage upstream of the second compressor between a branch point of the intake passage with the bypass passage and the second compressor, and a second intercooler installed in the intake passage downstream of the second compressor between a branch point of the intake passage with the bypass passage and the engine.

28. The supercharging device as defined in Claim 1, wherein the supercharging device further comprises a speed increase mechanism which connects the second compressor and the electric motor.